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ASTRID: The AMMUNITION SAFETY TEST REPORTS INTERNATIONAL DATABASE

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ABSTRACT

In a NIMIC specialists' meeting on Streamlining Safety Testing for Munitions, it was highlighted that the current NATO standardised way of carrying out IM testing and assessing munitions safety should be improved because of the low confidence level of the results / munitions responses. This is also sponsored by the AC310 / IM STANAG Experts' group in charge of drafting an AOP to support this STANAG. Under its Memorandum of Understanding, NIMIC makes a proposal for the benefit of its member nations to compile in a new database under formats - still to be agreed by its future users - the relevant and reliable safety test reports on generic mock-ups, test vehicles, components and munitions.

As of mid-1996, the NIMIC database comprise more than 20,000 documents and there are several databases on ammunition in use (usually restricted to an organization or a nation). The combination of these databases and the permanent analysis capabilities of NIMIC would enable NIMIC to create an "Ammunition Safety Test Reports International Database" (ASTRID) with the help of its 10 member nations. The NIMIC expertise would be a key asset for deleting the unreliable data and the already structured NIMIS database could provide an initial format for the safety test reports.

Then, with the means of a set of selection / elimination criteria established according to the State of the Art relating to the mechanisms involved in the threat / test configurations and described during NIMIC workshops, NIMIC would be able to release to the requester interested by a particular configuration a list of safety test reports relating to configurations meeting his selection requirements and "close to the configuration of interest for the requester". A major selection criterion is the involvement of the same controlling / dominant initiation mechanism as that of the configuration of interest for the requester. As a consequence, the statistical validity of the test responses could be improved or even the actual testing could be replaced by ASTRID predictions and modeling, which would be acceptable for some safety approval authorities for IM, as France.

The benefits are obvious - avoid duplication of testing and share data on the international arena, hence reduce the cost of development - and the drawbacks are on NIMIC.

The database will be useful, if and only if the potential users and benefactors release more recent data, as necessary with a caveat on the name of the munition / munition system.

This text describes the features and functions of the proposed ASTRID database, i.e. the types of data to be made available, the proposed datasheets for the main threats, the possible interactions with other databases, a selection process for retrieving the relevant datasheets, the benefits for the various categories of stake-holders and the political supports expected.

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INTRODUCTION

Carrying out a munitions safety testing or an IM testing means, as of today, a certain number of testing on components and all-up-round (2 for example for the NATO STANAG or MIL-STD 2105B on bullet impact) which, among others, present several major drawbacks:

- their low representativity and low reproducibility and, as a consequence, their low statistical validity because few of them are carried out, for a given munition or configuration of testing (in many civilian fields, a larger sampling is required for qualifying a batch) (1)
- their cost, particularly for large caliber warheads and rocket motors
- the small amount of information yielded, in some cases.

At a NIMIC Specialists' meeting in August 1994 on "Streamlining Safety Testing for Munitions", it was highlighted that the testing approaches should be reconsidered, such that AUR testing should be avoided, as often as possible, and replaced with test configurations that reliably represent basic stimuli and mechanisms and could provide reliable input data for models (2). At the end of 1994, AC310 drafted a Standardization Agreement (STANAG 4439) entitled "Policy for Introduction, Assessment and Testing for Insensitive Munitions (MURAT)". This document is undergoing ratification with the proviso that an Allied Ordnance Publication (AOP) supports it (3). The subsequent discussions (still in course but due to be finished at the end of 1996) within the ad hoc Experts's working group set to draft this AOP, insisted that AUR testing will be necessary but with improved testing procedures. NIMIC already proposed a procedure for Fragment Impact (4) and will organize in 1997 a series of workshops involving specialists in the fields of modeling and testing for drafting procedures for all the IM threats and safety assessment in the view of the AC310's approval.

<u>THE DATABASE FEATURES AND FUNCTIONS</u>

The features of the database proposed and described hereafter aim at supporting all the actions currently undertaken by NATO and NIMIC and at improving contacts and cross-fertilization between Program Managers, industry, testers, modellers, military users, munitions safety assessment, IM qualification authorities and accident investigators.

NIMIC proposes to improve the statistical validity of the past and future AUR testing as well as generic testing with the creation of an ammunition safety test reports database compiling data from international sources. The NIMIC Memorandum of Understanding signed between the 10 NIMIC member nations allow the logging of data up to "Confidential" or equivalent. Of course, there are already several major safety test reports databases in use but usually for the benefit of a particular country or, even worse, for the benefit of a particular service in a given country. The best known example is the NIMIS-II because it is widely advertised but it is usually restricted to the USA and the majority of the data compiled come from the Navy. As of August 1996, the ASTRID database does not exist yet at NIMIC but the availability in the open literature of a high number of safety test reports (unfortunately not well drafted or structured) make the prospects, despite of the efforts to be undertaken, very encouraging and free of charge to the munitions community. At this preliminary stage, the current assets, principles and future milestones are as follows:

<u>The datasheets</u>

In order to support the major IM threats, forms have been drafted at NIMIC for Bullet / Fragment Impact, Sympathetic Reactions between Munitions, Shaped Charge Jet Impact, and Fast or Slow Cookoff. (See attachments 1, 2, 3 and 4 respectively). They mention the following data:

. description of the threat / test configuration
. characteristics of the tested item / munition

. characteristics of the energetic material
. description of the test results, preferably according to NATO type reactions and not omitting the dominant mechanism leading to the reaction status of explosive qualification for safety and suitability for service and status of hazard classification
. number of similar test reports available
. sources of origin of data

These characteristics are based on the State of the Art and particularly on the relevant TTCP / NIMIC hazard protocols and the discussions during NIMIC workshops. They are considered as the most useful ones in view of understanding the response of the target against the threat. In order to prevent any misunderstanding in the jargon used, NIMIC will issue definitions and descriptions of these characteristics. It is highlighted that those in charge of funding and testing should aim at measuring and reporting as many data of these lists as possible, particularly those mentioned in the selection process (described in attachment 5). During the NIMIC workshops on Testing Procedures to be held in the course of 1997 for the major IM threats, an agreement should be reached among specialists on the entries necessary and / or useful for their specific needs: the selection process will focus on them.

<u>The benefit from similar configurations</u>

In the view of benefitting from the responses of similar configurations against similar threats, a list of the major questions (see attachment 5) has been drafted, highlighting the instrumental role of some parameters on the response to the threat. They have been established according to the State of the Art relating to the mechanisms involved in the threat / test configurations and described during NIMIC workshops; there is no arrangement by order of priority and the list is not yet comprehensive but open to discussions.

The requester would mention his own selection criteria and NIMIC would release him/her a list of safety test reports relating to configurations meeting his prescribed requirements and "close to the configuration of interest " (e.g. all the datasheets dealing with warheads, cast PBXs, RDX content between 50 and 55%, confinement between 5 and 6 mm). At that stage, a deeper analysis and common sense should be used at NIMIC (e.g. the proviso that the dominant mechanism should be the same for the configuration of interest and the datasheets selected might be necessary) before sending the selected datasheets to the requester and by the requester himself / herself.

The similar configurations could help predict (by simple comparison / extrapolations) the behaviour / response to the IM threats of the given configuration of interest under design or safety assessment in terms of probabilities of having such or such type of reaction; it would be more statistically satisfactory than stating "the munition burns when submitted to a fuel fire" because it occurred so during one or two single testing.

This "simple" approach does not aim at replacing modeling, such as the new approach advocated by NIMIC in (5), or actual testing, but rather supports or confirms them, at no extra cost to the ASTRID datasheets' users.

<u>The research programme and the use of the data retrieved</u>

The comparison described above will be supported by a specific research program selecting all the datasheets with an entry or several entries in common, with preselected "margins of error". The drafting of this program is not yet undertaken but it should be classical. As a consequence, the most important characteristics mentioned in the datasheets and highlighted in the selection process in Attachment 5 (and to be confirmed at the NIMIC workshops on IM Testing procedures in 1997) will be assigned a code, such as <XYZW> for the research process.

Security matters

The process of information up to "Confidential" is possible according to the NIMIC Memorandum of Understanding. For security reasons, the database will not be accessible from outside NIMIC but updated copies of the database with the research program could be made available on request (maybe not for the industrial organizations which will not significantly contribute), as it is now the case for the THAMES software updated versions distributed by NIMIC.

Confidentiality of information released

In order to put a caveat on the name of the specific munition / missile concerned by the test results, a code with capital letters will be proposed for each category of munitions, such as in THAMES and a figure assigned to each specific munition (the figures being kept secret at NIMIC), hence rendering the commercial-in-confidence information unrestricted. Nevertheless, it will always be possible for the source of information not to release at all the name of the munition / missile tested: well-recorded data are obviously more informative than the name of the munition involved in the test.

The custodianship

The ASTRID database will be under the custodianship of a NIMIC staff assigned half time or full time at least to this task, with the scientific support of the whole team. That will include in the first step the logging of the backlog consisting in safety test reports, either those mentioned in the open literature but never logged in a database or those included in scattered databases described hereafter. Nearly five years of daily use of the 20,000 references of the NIMIC databases convinced me that these reports were very numerous but not used in a fruitful manner. When answering enquiries on safety testing of a particular type of ammunition or explosives, e.g. antipersonnel mines, small arms ammunition, Octol as we did recently, the need for a well structured safety test reports database was strongly felt.

THE INTERFACES / OVERLAPS / CROSS-FERTILIZATIONS WITH OTHER DATABASES

There are a number of databases in various defense fields which content, structure and purpose could be useful in the view of logging data in ASTRID. The following list is obviously not comprehensive, because of the natural trend of not releasing data on safety testing which are also data on the vulnerability of the weapon systems involved in the operational use of the munition tested. It aims at convincing the readers who are also potential benefactors of ASTRID that data are scattered and are most probably duplicate of others logged in other databases. The list is as follows:

- NIMIS II is the best known database in safety assessment. It was initially created by the US Navy who released the majority of the data but transitioned to a tri-service system in 1991 and consists in 3 different databases:
. the Munitions Status Information Center (MSIC)
. the IM Engineering Technology (IMET)
. the Energetic Materials Information Center (EMIC)

containing weapon specific tests data, generic weapons technology development tests, as well as explosive and propellant data, compiled such that they will accommodate all services test reporting methods and retrieved from 2,000 documents.

Obviously, a significant number of the entries used within the NIMIS database are similar to those mentioned in the NIMIC-proposed datasheets in attachments 1-4 but there are important gaps in the scientific requirements,

particularly in view of understanding the mechanisms involved in the reaction of the energetic materials / munitions. As it is already planned for a particular country under a specific bilateral agreement, NIMIC should also benefit in the near future from the reports not specific to a munition or a missile.

- The NATO Ammunition Data Base (NADB), being developed by the NATO Maintenance and Supply Agency (NAMSA) based in Capellen, Luxembourg will compile data on all NATO ammunition and explosive items. The data relates to transportation, storage, technical characteristics and interchangeability for authorities responsible for ammunition logistics. Technical descriptions will include information such as filler type, propellant, Net Explosive Mass, packaging dimensions etc. According to the Project Officer, it is planned to add an information box, in future editions, mentioning the existence of safety test results; then it would be up to NIMIC, or other NADB users, to contact the relevant authorities in charge of the munition to get more precise data on safety test results. NIMIC will work with NAMSA to include the proposed NIMIC datasheet forms on the NADB Compact Disks which are expected to be distributed to a wide range of ammunition organizations world-wide. The NIMIC visit to NAMSA confirmed the obvious cross-fertilization between logistics, ammunition interchangeability and safety assessment and the proposed NIMIC datasheet would give a much better safety picture to logisticians than a simple hazard classification rating. The first release of the NADB is planned for the autumn of 1996 and it will be available on subscription for a reasonable annual fee.

- in 1992, the French NIMIC Focal Point (GERBAM) released a rough database of 100 French safety test results relating to missiles and munitions out of a much more comprehensive database, not released to NIMIC;

- regularly, the UK Ordnance Board proceedings describe safety test results relating to munitions under qualification; they include some of the characteristics listed in the NIMIC proposed datasheets;

- some data yielded by EOD activities, even if not well recorded for the purpose of safety assessment, might also be useful; this is the case for a Dutch Air Force database.

<u>THE BENEFACTORS</u>

This NIMIC initiative should be particularly welcome in this period of stringent defense budget constraints all over the world. Provided they are from NIMIC nations, all the following categories of stake-holders would benefit of a worldwide, albeit NIMIC-wide effort for compiling safety test reports and more particularly, the IM testing type. The straightforward benefits are described hereafter.

<u>The Program Managers</u>

In the conducting of a programme, the current trend is to devote more effort to performance testing than safety testing. The minimum quantity of tests required by the safety qualification authorities is carried out and, as a consequence, the results have a low confidence results. The records can not be trusted sometimes. A more extensive use of models and a comprehensive screening of ASTRID would help devote the safety testing funds to the analysis of the State of the art and to those tests really necessary for a better understanding of the hazards faced by the munition and not only to those requested by a standardised method.

<u>The industry</u>

In the view of bidding for requests for proposal (RFP) with fixed parameters such as munition dimensions, confinement, type of explosive filler, etc..., the industry actors could use, among other means, the extensive ASTRID database to select the best compromise performance - safety to meet the RFP requirements. Even the

marketing managers have to be aware of such a tool to achieve quick and cheap safety assessments.

The modellers

The modellers who work or should work closely with the testers will either get potential input data for their modeling activities or data to validate their predictions by interpolating or extrapolating results relating to test configurations of interest for them.

The safety testers

ASTRID would be an ideal means of advertising the availability of the test facilities of a proving ground as well as the skills of the testers and the instrumentation used. Using the records of similar threat / munitions configurations from other proving grounds, parameters of the configuration to be studied could be adapted in order to highlight a particular phenomenon.

The safety assessment / hazard classification / IM qualification authorities

The datasheets will remind of the status of Safety and Suitability for Service and Hazard Classification without releasing detailed information. Other means, e.g. publications or databases or qualification files, are supposed to deal with these fields.

According to the new "demonstration approach" for IM testing allowed in the French doctrine for developing MURAT (IM in French), it could be possible to avoid AUR testing if other sources of information or analysis could reliably replace them. Here again, the use of safety test reports relative to similar configurations could be most useful.

The military users

Whenever they would have concerns about the hazards faced by their munitions during storage, transport or use, they could enquire about the response of the same munition, as well as the responses of similar munitions / configurations.

The accidents investigators

After accidents occur, it is sometimes difficult to find reliably their primary cause. The research of testing configurations similar to those suspected to be the causes of the accidents as well as the study of the test reports might give clues to the investigation teams. Such enquiries, e.g. a recent helicopter accident where ammunition were involved, would be facilitated by ASTRID reports.

THE POLITICAL SUPPORTS

Obviously, a strong political support of at least the major contributors to the NIMIC database, i.e. the US, the UK and France, as well as the other NIMIC member nations (Australia, Canada, Italy, the Netherlands, Norway, Portugal, Spain) via their authorities (representatives at the NIMIC Steering Committee and at the NATO AC 310 group) would be beneficial to trigger the release of safety test reports from the potential sources in these nations, preferably meeting the NIMIC datasheets formats. The roles of the national information centers, e.g., DTIC, CPIA, DRIC or CEDOCAr or the so-called NIMIC focal points could be instrumental in forwarding the reports.

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(3) Standardization Agreement (STANAG 4439) on "Policy for Introduction, Assessment and Testing for Insensitive Munitions (MURAT)", AC/310, December 1994

(4) H. BOCHER, "Analysis of Fragment Impact Tests", NIMIC / ENSIETA, Restricted, June 1996

(5) A. SANDERSON and E. THIVILLIER, "A New Approach to Assessment and Design of Insensitive Munitions by Analysis of Critical Mechanisms that may be Initiated by Unplanned Stimuli", NIMIC and ENSIETA, the DDESB Explosives Safety Seminar, Las Vegas, August 1996

Attachment 1

SAFETY ASSESSMENT DATASHEET
for
BULLET / FRAGMENT IMPACT

Projectile

- Type (bullet, fragment preformed or not, sphere, cylinder, shape..)
- Mass
- Material with mechanical properties (Young modulus, maximum stress, strain failure criteria, EOS, constitutive model...)
- Obliquity at impact (theoretical and/or measured)
- Velocity at impact (theoretical and/or measured)
- Yaw/pitch at impact
- Origin (explosively formed, gun launched, ...

Tested item/munition (excluding the energetic material)

- Type (munition, dummy, test vehicle, ...) and name, if non confidential/limited
- Purpose (warhead, gun cartridge, propulsion unit, booster, igniter, other...)
- Purpose of test (research, development. disposal)
- Material and its mechanical properties (same as projectile plus specific weight, shock Hugoniot)
- Dimensions (diameter, length, thickness, other as necessary...) including for end plates
- Theoretical static burst pressure, particularly for test vehicles
- Shock Hugoniot
- Presence of vents
- Presence of liners
- Prestressing information (ageing, vibration, shock, humidity...)
- Qualification status
- Hazard classification status

Test article energetic material

- Name, code
- Storage conditions with date of fabrication
- Quality control, if any
- Type (high explosive, rocket propellant, gun propellant)
- Family of substance (melt-cast, cast cured PBX, pressed PBX, composite...) and formulation of all EM in test (high explosive, propellant, igniter, booster transfer lines, etc.) - at least fractions of total solids, oxidiser, fuel and binder types and whether catalysed
- Average particle size, shape...
- Mechanical properties (same as tested item/munition plus TMD or porosity, shear, average particle size, particles shape, ...
- Thermal diffusivity
- Critical diameter, velocity of detonation
- Popolato plot
- Card gap tests responses (various diameters/porosities)

- Reactive models
- Friability or Susan test
- Geometry

NATO type reaction observed

- Dominant mechanism or Critical Initiation Reaction Mechanism
- Reaction type
- Location of the ignition site
- Temperature-time map of charge
- Detailed description of fragments patterns (number, size, velocity...)
- Secondary effects following the response
- Delays for initiation and transition to various levels of reaction
- Instrumentation used in the target and vicinity: pressure gauges, witness plates, time of arrival gauges, ionization gauges, high speed cinematography, still camera, video frame rates

Number of similar tests reports available

- A sheet should be drafted for every test, even if configuration is not changed.

Sources of origin of data

- NIMIC
- NIMIS-II
- Other databases

Confidence level of data

- Mention availability of modelling predictions
- Mention the existence of tests data on similar configurations

<u>Attachment 2</u>

SAFETY ASSESSMENT DATASHEET
for
SYMPATHETIC REACTIONS

Configuration geometry

Location of donor(s)
Location of buffers
Location of acceptor(s)

Donor munition (s)

- Design details
- Explosive or propelling charge
- Pressure or flame output
- Output direction
- Output duration

Acceptor munition(s) (excluding the energetic material)

- Type (munition, dummy, test vehicle) and name, if non confidential/limited
- Purpose (warhead, propulsion unit, gun cartridge, booster, igniter, other...)
- Purpose of test (research, development. disposal)
- Material and its mechanical properties (specific weight/Young's modulus/maximum stress/strain failure criteria, EOS, constitutive model, shock Hugoniot)
- Dimensions (diameter, length, thickness, others as necessary...) including for end plates
- Theoretical static burst pressure, particularly for test vehicles
- Presence of liners
- Presence of vents
- Prestressing information (ageing, vibration, shock, humidity...)
- Qualification status
- Hazard classification status

Test article energetic material of the acceptor(s)

- Name, code
- Type (high explosive, rocket propellant, gun propellant)
- Family of substance (melt-cast, cast cured PBX, pressed PBX, composite...) and formulation of all EM in test (high explosive, propellant, igniter, booster transfer lines, etc.) - at least fractions of total solids, oxidiser, fuel and binder types and whether catalysed
- Storage conditions with date of fabrication
- Quality-control, if any
- Thermal diffusivity
- Mechanical properties (same as acceptor munition plus TMD or porosity, shear, average particle size, particles shape, ...)
- Critical diameter, velocity of detonation

- Shock Hugoniot
- Popolato plot
- Card gap tests responses (various diameters/porosities)
- Reactive models
- Friability or Susan test
- Calibrated shock wave
- Flyer plate tests
- Wedge test

NATO type reaction observed

- Dominant mechanism or Critical Initiation Reaction Mechanism
- Reaction type
- Location of the ignition site
- Temperature-time map of charge
- Delays for initiation and transition to various levels of reaction
- Detailed description of fragments patterns (number, size, velocity...)
- Instrumentation used in the target and vicinity (shock velocity gauges, pressure gauges, time of arrival gauges, witness plates, high speed cinematography, ionization gauges)
- Instrumentation for secondary effects following the response (narrow and broad angles radiometers, convective heat flux gauges, real time and high frame rate videos, still photograph for debris patterns)

Number of similar tests reports available

- A sheet should be drafted for every test, even if configuration is not changed.

Sources of origin of data

- NIMIC
- NIMIS-II
- Other databases

Confidence level of data-

- Mention availability of modelling predictions
- Mention the existence of similar tests data

Attachment 3

SAFETY ASSESSMENT DATASHEET
for
SHAPED CHARGE JET IMPACT

Projectile

-density (type of liner material)
-velocity (of each fragment), velocity gradient
-fragmented/non fragmented, lateral velocities, tumbling of particles
-diameter/shape (of each fragment if fragmented)
-standoff
-V^2D of impacting part of jet (if it cannot be derived from the above data)
-mechanical properties (Hugoniot)
- presence and position of attenuators

Tested item/munition (excluding the energetic material)

- Type (munition, dummy, test vehicle, ...) and name, if non confidential/limited
- Purpose (warhead, gun cartridge, propulsion unit, booster, igniter, other...)
- Purpose of test (research, development. disposal)
- Material and its mechanical properties (Hugoniot, yield strength, moduli)
- Dimensions (diameter, length, thickness, other as necessary...) including for end plates
- Theoretical static burst pressure, particularly for test vehicles
- Presence of vents
- Prestressing information (ageing, vibration, shock, humidity...)
- Qualification status
- Hazard classification status

Test article energetic material

- Name, code
- Storage conditions with date of fabrication
- Quality control, if any
- Type (high explosive, rocket propellant, gun propellant)
- Family of substance (melt-cast, cast cured PBX, pressed PBX, composite...) and formulation of all EM in test (high explosive, propellant, igniter, booster transfer lines, etc.) - at least fractions of total solids, oxidiser, fuel and binder types and whether catalysed
- Average particle size, shape...
- Mechanical properties (same as tested item/munition plus TMD or porosity, shear, average particle size, particles shape, ...
- Thermal diffusivity
- Critical diameter, velocity of detonation
- Popolato plot, run to detonation distance
- Card gap tests responses (various diameters/porosities)
- Data on shock sensitization/desensitization, if any
- Reactive models
- Geometry

- Relevant V^2D and/or U^2D thresholds (for bare/thinly covered/thick covered EM)
- For gun propellants: is the EM known to react proportionnaly to V3?
- If several EM are used, details of geometry are needed and the above characteristics are needed for all of these EM

Testing conditions

-Temperature

NATO type reaction observed

- Dominant mechanism or Critical Initiation Reaction Mechanism
- Reaction type
- Location of the ignition site
- Detailed description of fragments patterns (number, size, velocity...)
- Secondary effects following the response
- Delays for initiation and transition to various levels of reaction
- Instrumentation used in the target and vicinity: pressure gauges, witness plates, time of arrival gauges, ionization gauges, high speed cinematography, still camera, video frame rates

Number of similar tests reports available

- A sheet should be drafted for every test, even if configuration is not changed.

Sources of origin of data

- NIMIC
- NIMIS-II
- Other databases

Confidence level of data

- Mention availability of modelling predictions
- Mention the existence of tests data on similar configurations

Attachment 4

SAFETY ASSESSMENT DATASHEET
for
FAST or SLOW COOKOFF

Configuration geometry and description of heat source

- Description of heat source (fuel fire, propane, burner heads, baffles, etc., heater elements around test article, insulation environment, etc.)
- Location of test article relative to heat source

Tested item/munition (excluding the energetic material)

- Type (munition, dummy, test vehicle, ...) and name, if non confidential/limited
- Purpose (warhead, gun cartridge, propulsion unit, booster, igniter, other...)
- Purpose of test (research, development. disposal)
- Description of how test article is mounted and restrained in heating environment
- Container/ case material and its mechanical properties, including elevated temperatures of properties to point of case decomposition
- Dimensions (diameter, length, thickness, others as necessary...) including for end plates, nozzle, etc.
- Theoretical static burst pressure, particularly for test vehicles
- Description of mitigation devices and/or vents, if any
- Description, mechanical and thermal properties of case external and internal insulation and liner materials
- Description of igniter or fuse case, if included in test vehicle
- Prestressing information (ageing, vibration, shock, humidity...)
- Qualification status
- Hazard classification status

Test article energetic materials

- Type (high explosive, rocket propellant, gun propellant) and names/identifications of all EMs in test article
- Design details and geometric configuration of all energetic materials (EMs) (including burning surface area)
- Family of substance (melt-cast, cast cured PBX, pressed PBX, composite...) and formulation of all EM in test (high explosive, propellant, igniter, booster transfer lines, etc.) - at least fractions of total solids, oxidiser, fuel and binder types and whether catalysed
- Mechanical properties of all EMs in test as a function of temperature up to the initiation point of EMs. (specific weight/Young's modulus/maximum stress/strain failure criteria, EOS, constitutive model) plus TMD or porosity, shear, average particle size, particles shape, ...)
- Critical diameter, velocity of detonation
- Card gap tests responses (various diameters/porosities)
- Reactive models
- Friability or Susan test
- Storage conditions with date of fabrication
- Quality-control, if any
- Thermal properties (thermal diffusivity, density & specific heat) of all EMs in test as a function of temperature up to the initiation point of EMs.
- Burning rate of EMs as function of pressure (1 to at least 200 atm.) and initial temperatures up to ignition temperatures of EMs in test article

- Thermochemical properties of all energetic materials
- Activation energies and ignition temperatures as function of heating rates and heat sources for all EMs in test article
- Description of physical & chemical states of all EMs with temperature and heating rates up to the points of initiation and/or activation energies for each EM

Test results and NATO type reaction observed

- Dominant mechanism or Critical Initiation Reaction Mechanism
- Reaction type
- Description of meteorological conditions at time of test (iar temperature, humidity, wind direction and velocity)
- Location of the ignition site in munition
- Temperature-time map of charge
- Delays for initiation and transition to various levels of reaction
- Detailed description of fragments patterns (number, size, velocity...)
- Description of and results from all instrumentation used in the target and vicinity (thermocouples, internal to test article and external, fiber optic output, Infra red and ultra violent sensors, shock velocity gauges, pressure gauges,tTime of arrival gauges, witness plates, high speed cinematography, ionization gauges)
- Instrumentation for secondary effects following the response (narrow and broad angles radiometers, convective heat flux gauges, real time and high frame rate videos, still photograph for debris patterns)
- Instrumentation to describe/define heat source intensity as a function of time

Number of similar tests reports available

- A sheet should be drafted for every test, even if configuration is not changed.

Laboratory and sub-scale tests conducted on materials

- Description of tests including materials, confinement, instrumentation, locations, heat source, heating rates, etc, and results of tests

Sources of origin of data

- NIMIC
- NIMIS-II
- Other databases

Confidence level of data

- Mention availability of modelling predictions
- Mention the existence of similar tests data

Attachment 5

DATASHEETS SELECTION PROCESS

Here are questions regarding the item (case + energetic substance) studied and/or to be tested, on one hand, and the type of threat considered, on the other hand. The "margins of error" are suggested by NIMIC but a requestor will be free to adapt them to his specific case.
(Note that "Munition" may also mean item tested, mock-up..).

Case + Energetic substance

- Has the charge been already damaged or shocked?

- Check geometries of confinement and explosive/propelling charge. Eliminate some datasheets, accordingly.

- What is the type of the munition considered (rocket motor, warhead, gun cartridge)?

- What is the material of the radial confinement? Select those with the same family of materials (e.g. steel or aluminium based) and, as necessary, with the same shock Hugoniot and/or elastic moduli/ dynamic failures?

- What are the dimensions of the munition: diameter, length, thickness (lateral and radial)? Select those with the same diameter +/- 20 % and radial thickness +/- 10%.

- Check availability of vents. Compare theoretical burst pressures, if available.

- What is the type of formulation (melt-cast explosive, cast PBX, pressed PBX, composite propellant, cast double base propellant, elastomeric modified cast double base, single base, triple base, etc...)? Select those with the same type of formulation?

- What is the type and fraction of total solid contents?

- What is the % of each major solid content? Select those with the same % of solid contents +/- 2% total solid.

- What is the type of binder?

- What is the % of binder?

- Is there is a gap between the case and the charge ? Select on priority the same type of datasheets but no strict elimination should be decided on the basis of that criterion.

In case of a SD threat

- What are the card gap test responses, the Pop plots and the shock Hugoniot of the explosive substance tested ? Select those with the same data +/- 30 % (for at least one of them).

- What is the donor (confinement, high explosive)? Select those with the same output, i.e the same number of donors, the same confinement (material, thickness +/- 10%) and the same high explosive (same rho d2/4 or Energy +/- 10%).

- What is the configuration (hexagonal, square. one-to-one, one-to-two, other)? Select those with the same configuration.?

- Are there buffer(s)? If yes, what type of buffers? Select those with buffers (same type only) or no buffer.

- What is the distance(s) between the buffer(s) and the donor(s)? Select those with a similar distance +/- 15%.

- What is the distance between the 3 closest acceptors with the donor? Select those with the same average similar distances +/- 15%.

<u>In case of a bullet / fragment impact</u>

- Which type of projectile (bullet, sphere, cylinder, other)? Select those with the same geometry (the number of projectiles is less relevant).

- What are the friability data of the explosive substance? Select those with the same data +/- 25%. (It is not yet decided if the dynamic failure is relevant for crack initiation/propagation).

- What is the projectile velocit ? Select those with the same velocity +/- 10%.

<u>In case of slow cookoff</u>

- What are the thermal diffusivities of the confinement material and the explosive substance? Select those with the same data +/- 20 %.

- What is the reaction temperatur ? Select those with a temperature +/- 20 C.

- What is the binder? What is the oxidizer? If EM is a propellant, what is the burning rate versus pressure relationship and is propellant catalysed?

<u>In case of fast cookoff</u>

- What are the thermal diffusivities of the confinement material and the explosive substance? Select those with the same data +/- 20%.

- What is the reaction temperature? Select those with a temperature +/- 20 C.

- What are the friability data of the explosive substance? Select those with the same data +/- 25%. (It is not yet decided if the dynamic failure is relevant for crack initiation/propagation).

<u>In case of Shaped Charge Jet Impact</u>

- What is the V2D of the jet (after attenuators)? Select those with the same criterion +/- 10%.

- What is the V2D sensitivity threshold of the filler? Select those with the same threshold +/- 10%.